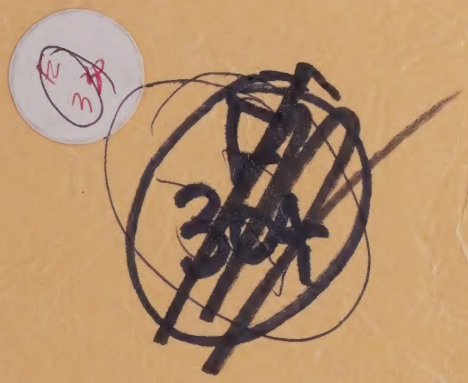
6C 95

# INSTRUMENT
# INSTRUCTIONS



SENSITIVE RESEARCH
INSTRUMENT CORPORATION
NEW ROCHELLE, N.Y.

Symbol of Quality

ELECTRICAL INSTRUMENTS OF PRECISION SINCE 1927

Instrument No.

# INSTRUCTION MANUAL

FOR THE

## REPLACING AND CALIBRATION

of Type 357

# VACUUM THERMOCOUPLES

IN OUR INSTRUMENTS

Models A - AU - U - USP and U-88

April 3, 1958

SENSITIVE RESEARCH
INSTRUMENT CORPORATION
NEW ROCHELLE, N.Y.

Symbol of Quality

ELECTRICAL INSTRUMENTS OF PRECISION SINCE 1927

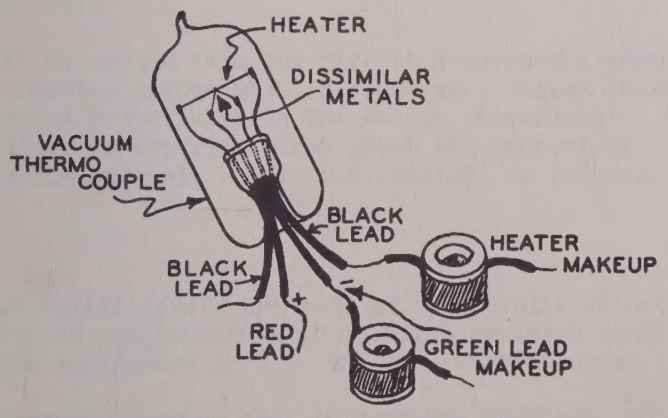
TYPE 357 TRF REPLACEMENT COUPLES

(357 = MARCH 1957)

The TRF, (Thermocouple Replacement Feature) applied to our thermocouple instruments, allows field replacement of burned out couples WITHOUT the necessity of returning the instrument to the factory.

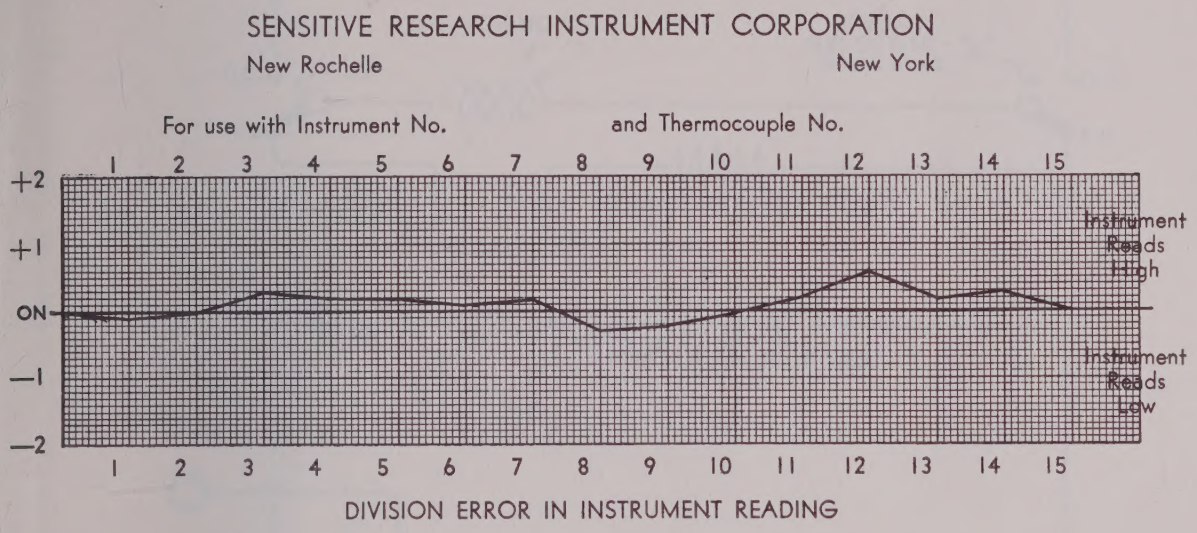
Instruments for which the Type 357 replacement couple can be supplied will have a decal label on the instrument case bottom near the thermocouple removable black bakelite cap, signifying that the millivolt calibration of the instrument has been recorded by us. This calibration record is ABSOLUTELY NECESSARY to use the 357 Type replacement couple method. Instruments not incoporating this 357 feature, must be returned to factory for recording of this instrument calibration data. Type 357 couples are furnished with the necessary matching resistors and with a correction chart which allows their use to the full rated accuracy of the instrument.

Replacement couples are obtained by ordering them from SENSITIVE RESEARCH and specifying "Replacement couple for instrument #_____." The type 357 thermocouple when received by the user, will have attached to it two resistances which are to be used to replace the two resistances in the instrument. One resistance is in series with one of the black leads. This resistance is to bring the heater resistance up to a standard value to insure exact range multiplication (either current or voltage). The second resistance is used to adjust sensitivity and it is connected in series with the green junction lead. Care should be used to insure installing the new resistances and couple exactly as the original was connected.




TYPE 357 THERMOCOUPLE ASSEMBLY

Accompanying the replacement couple will be a typical correction chart as shown below:


SENSITIVE RESEARCH INSTRUMENT CORPORATION
New Rochelle
New York
For use with Instrument No.
and Thermocouple No.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
+2
+1
ON
—1
—2
Instrument Reads High
Instrument Reads Low
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
DIVISION ERROR IN INSTRUMENT READING

Type 357 couples are furnished with the necessary matching resistors and with a correction chart which allows their use to the full rated accuracy of the instrument.

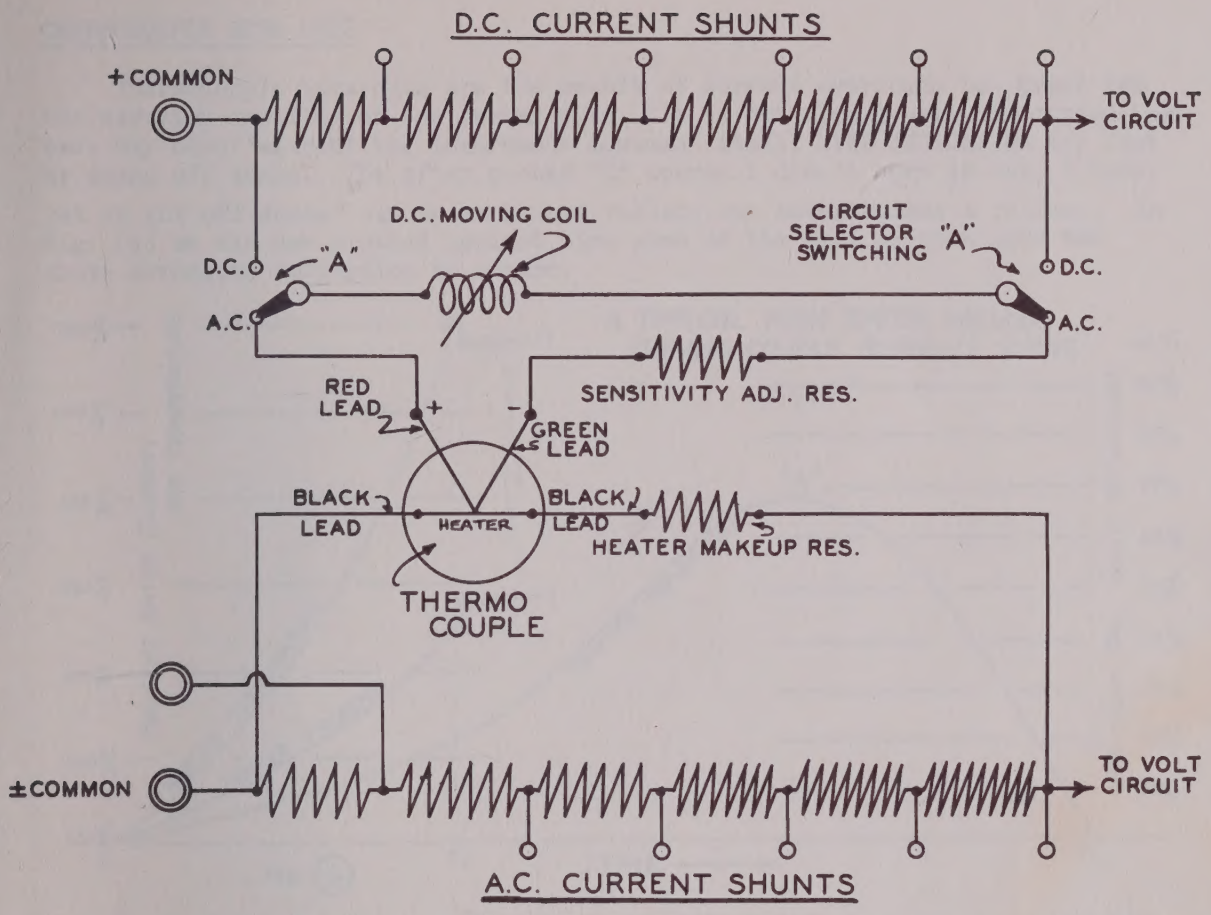
## REPLACEMENT OF THERMOCOUPLE ON UNIVERSAL POLYRANGER

Our UNIVERSAL POLYRANGER is an instrument that measures D.C. and A.C. It consists of a Universal shunt circuit on D.C. which is across a D'Arsonval D.C. moving coil.

On A.C. we switch into the circuit a universal shunt of different value which is connected across what is known as a Vacuum Thermocouple. When current flows through a heater wire in the vacuum thermocouple, it produces a small direct current voltage in two fine wires which are mechanically connected to the heater wire of the thermocouple. This D.C. voltage is fed into the D'Arsonval moving coil.

Both universal shunts are made up of definite values of resistances so designed that in conjunction with selector switches we obtain the various ranges of the instrument in D.C. and A.C. current or voltage.

The D'Arsonval moving coil is switched FROM the D.C. universal shunt to the A.C. thermocouple shunt circuit as desired by the user.



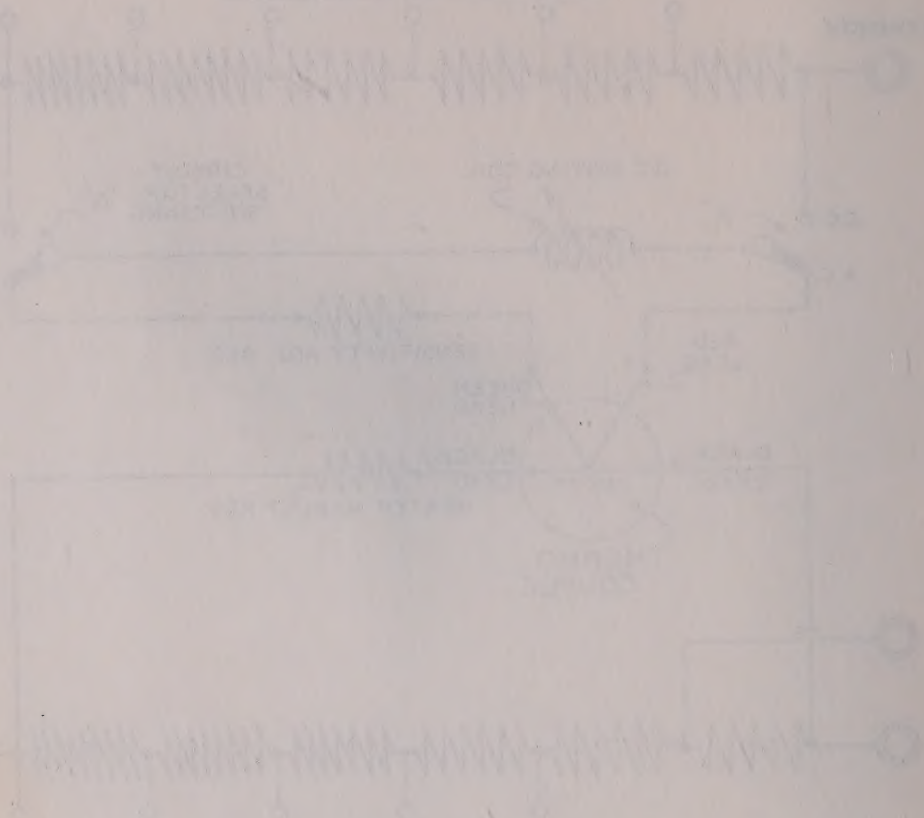

BASIC CIRCUIT OF MODEL U-USP-U-88 INSTRUMENTS

## THERMOCOUPLE OVERLOADING

All vacuum thermocouple instruments, irrespective of their maker, will not stand overloads over 100% without damage to the thermocouple.

A special precaution which should be taken by the user of thermocouple instruments is to avoid opening the primary circuit of a transformer whose secondary circuit is being measured by thermocouple instruments. The reason for this is, that the transformer as an energy storing device, may, under certain conditions, discharge its energy into the secondary circuit, thereby overloading the thermocouple instruments. This danger can be eliminated by either disconnecting the instrument from the secondary circuit before opening the primary ciruit or by including a Variac in the primary circuit so that the excitation of the primary may be reduced to zero before switching off.

Unfortunately, at times, the vacuum thermocouple becomes burned out and must be replaced.



## THERMOCOUPLE BURN-OUTS

Thermocouple burn-outs are the result of current overloads too great for the carrying capacity of the heater wire. It is not always well understood that this may occur without the instrument movement itself EVER INDICATING the fact by going off scale. The often quoted "Of course I didn't burn it out, I never let it get off scale" can be an honest fallacy but nevertheless a fallacy. In Fig. (4) we can see plotted against time some of the factors that make the above erroneous assumption so common.

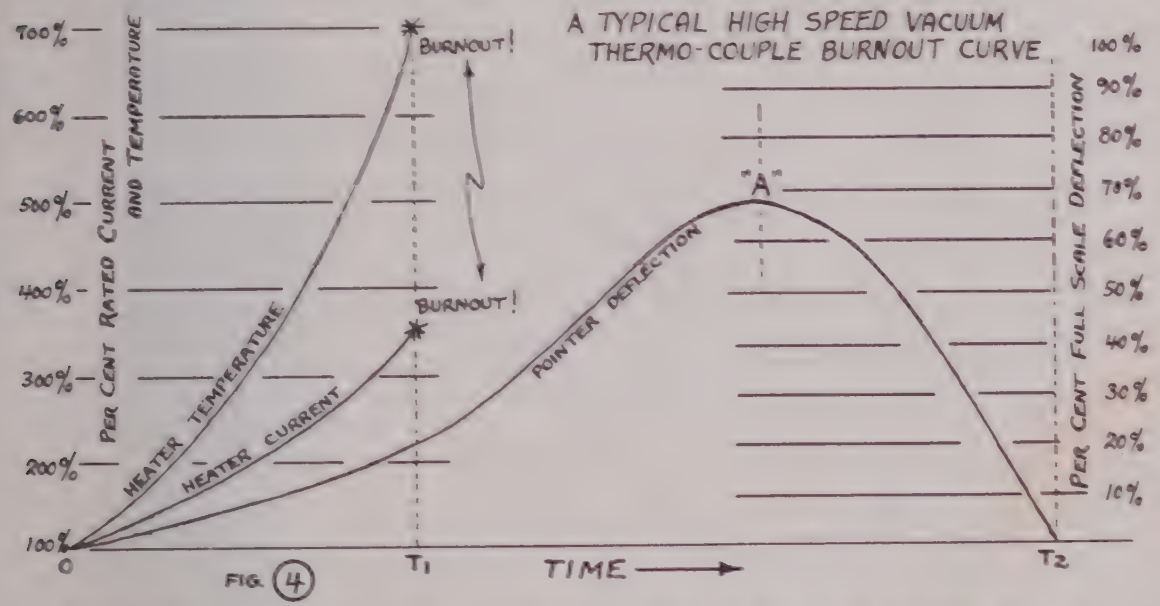



FIG. (4)

The heater current is shown rising with time to burn out at time T1. The corresponding temperature of the heater is seen to rise at a rate nearly the SQUARE OF THE HEATER CURRENT. This is possible because the heater wire is very fine and has little thermal capacity. The temperature will then lag the theoretical heater current squared relationship by a very little bit when that current is raised at a rapid rate. The temperature rises to several hundred percent of the value at normal current and eventually reaches the fusion point and melts at time T1 and interrupts the current.

If we look at the pointer deflection curve however we see a quite different picture. The millivoltmeter movement used in the instrument is very highly damped by the junction circuit and as a result cannot deflect at a very rapid rate. As a result if time T1 is very short, let us say in the order of a tenth second the pointer will not reach a great deflection. The pointer will at time T1 have some kinetic energy due to it's motion and will continue to coast to a somewhat higher reading and then start falling back to zero at time T2. The times T1 and T2 will vary greatly for different types of couples and different rates of current rise. There are many, many combinations of current and rate of rise however for which point "A" will be well under full scale value and the couple be burned out without ever indicating an "off scale" value.

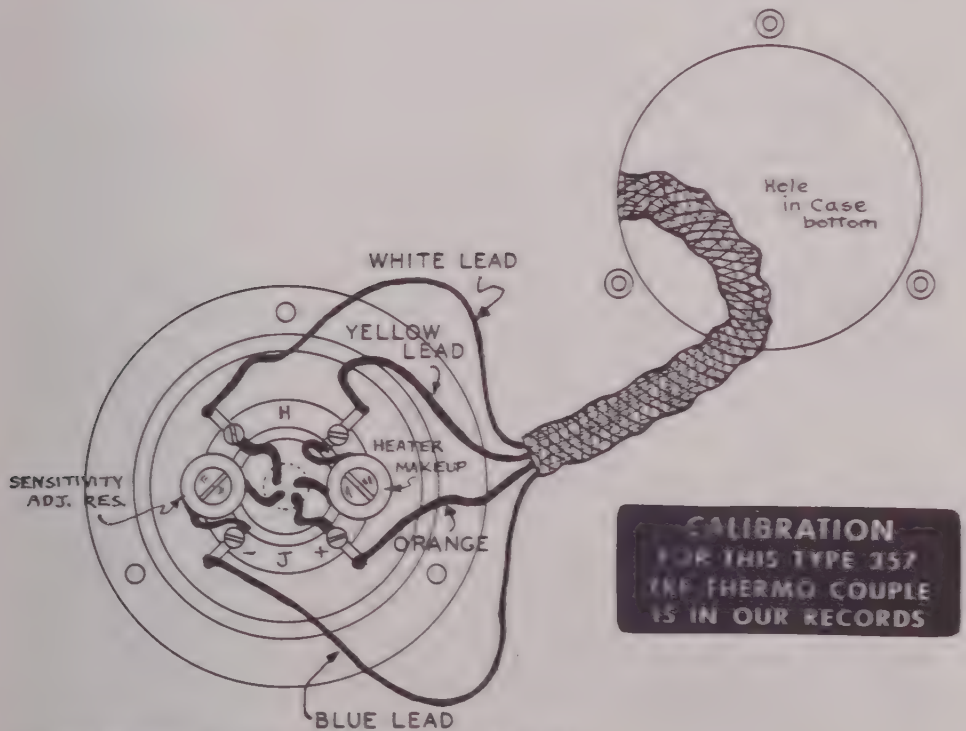
The above type of burn-out is usually a transient condition due to either capacitive or inductive stored energy being released into the circuit inadvertently. All circuits in which thermocouples are to be used should be carefully scrutinized with this possibility in mind.

## TO REPLACE A THERMOCOUPLE IN OUR MODEL U - USP - 88

Do not attempt to replace a thermocouple in a room where there is excessive dirt or any magnetic particles about. There is a possibility that these particles will be attracted into the strong magnetic gap of the moving coil, thus causing a sticky movement.

To remove the thermocouple holder, turn the instrument upside down. Remove 3 phillips head screws from the bakelite cap. Pull the bakelite thermocouple container out about 3 inches from the wooden case. There are 4 flexible wire leads connecting the thermocouple to the internal circuitry of the instrument. Turn the bakelite thermocouple container over so that the cap of the holder is lying flat on the bottom of the instrument case.

The thermocouple is a small glass bulb 1/2" in diameter x 3/4" long that is installed in the bakelite holder located in the bottom of the instrument case. There are four leads. (two black, one red and one green) protruding from the base of the thermocouple. The black covered leads are called heater leads. Thery are connected to the ends of the thermocouple heater element. The red and green leads are called junction leads. (Two dissimilar metal wires. welded to the center of the heater element.) The red lead is the (+) positive side of the D.C. millivolt output, and the green lead the (-) minus side of the D.C. millivolt output.




VIEW OF TYPE 357 ASSEMBLY
WHEN USED ON MODEL U-USP-88
POLYRANGERS

The replacement thermocouple as received from us will be accompanied by two 1/4" resistance bobbins. One of these resistance bobbins, as shown on the sketch, (page ) is to be connected in series with the heater (one of the black wires). This will be referred to as the heater make up. This resistance brings the internal resistance of the thermocouple up to a certain definite value which enables the universal shunt circuit to work correctly in all its ranges. The other 1/4" resistance bobbin adjusts the D.C. output of the thermocouple to exactly full scale on the instrument. This is referred to as the sensitivity adjustment resistance.

With the thermocouple there will be two small resistances. One resistance (a low value of approximately 2.5 ohms) is connected in series with one of the black heater leads. The other end of this resistance is to be soldered to one of the connection lugs marked "H". The other resistance (approximately 10-25 ohms) is connected in series with the green lead. The other end of this resistance is soldered to a connecting lug marked - (minus). The red lead is soldered to a connecting lug marked + (plus) and the other black lead of the thermocouple is soldered to the remaining lug marked "H".

To remove the old thermocouple unsolder the following leads from the moulded bakelite holder.

1. "Red" thermocouple lead from the plus connection lug.

2. The end of the resistance that goes to the minus connection lug.

3. The "Black" lead from the H. connection lug.

4. The end of the resistance that goes to the other H. connection lug.

Remove the flat head machine screws that hold the 2 resistances in place, grasp the four thermocouple leads near the base of the thermocouple and pull straight up. In our later models the thermocouple is installed in a piece of white rubber tubing. When you lift the thermocouple out, the rubber tubing may come out with the thermocouple. If it does, merely pull the thermocouple out of the tubing. Then slip the new thermocouple into the tubing and insert them into the bakelite thermocouple holder, glass point down. Solder the thermocouple leads with the 2 resistances which are supplied with the thermocouple back into place, (see page 184). Set the thermocouple container back into the bottom of the case and replace the 3 phillips head screws.

While the foregoing appears to be quite complicated it can be done by a careful person in a very few minutes. One caution we would like to add when using Vacuum Thermocouple instruments, is to be sure the instrument is disconnected from any secondary circuit of a transformer before the primary circuit is opened. We find the cause of most burn outs is the inductive surge caused by opening the primary circuit when the thermocouple instrument is connected in the secondary circuit. Such surges may run 400% and 500% over the normal current or voltage reading of the range being used, and thus cause the thermocouple to burn out.

It is possible to overload a thermocouple and not burn it out but its characteristics will change. When a thermocouple is severely overloaded the instrument will no longer be within its rated accuracy. However, this does not mean that in an emergency the instrument cannot be used, if the overload has not been too severe and the user has means of calibrating the instrument.

If the instrument reads high after an overload some resistance has to be added to the sensitivity adjustment bobbin (10-25 ohms soldered to the end of the green thermocouple lead).

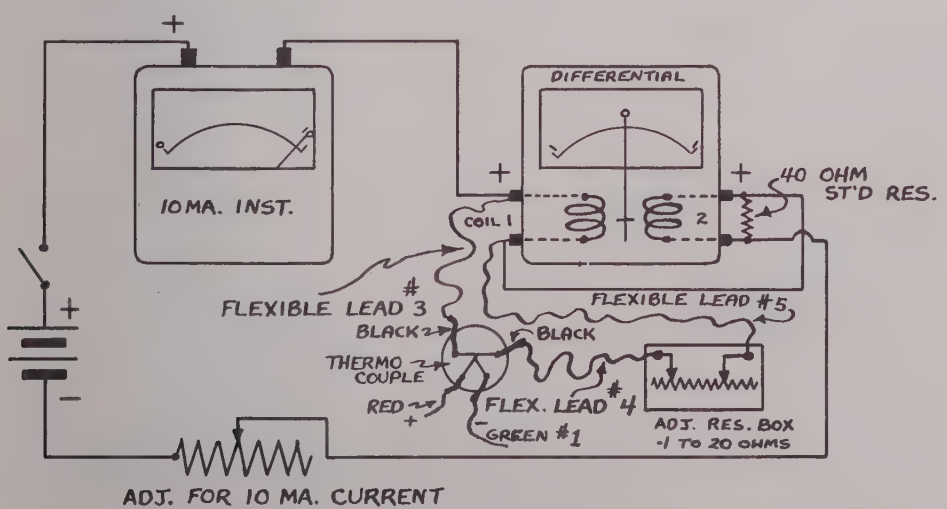
If the instrument reads low after an overload take some resistance out of the sensitivity adjustment bobbin. Have the thermocouple replaced as soon as possible, because while the top point of the scale has been made to check, this does not mean that all the points on the scale will check with the guararteed accuracy.

Necessary equipment required to adjust the resistances of a thermocouple so as to match the full scale top point on our instrument.

1. A variable resistance box, (adjustable from .1 ohm to 20 ohms).
2. 8 feet of #28 flexible insulated copper wire cut in approximately 2 foot lengths.
3. A Wheatstone bridge.
4. A standard 10 milliampere D.C. full scale instrument.
5. A differential instrument (1-0-1 Ma.) resistance of each coil to be exactly 120 ohms.
6. An adjustable D.C. current supply.

Remove the sensitivity resistance (on the green thermocouple lead) and solder a flexible lead, approximately 2 feet long to the green thermocouple lead, which we will refer to as flexible lead #1, also solder a flexible lead two feet long to the minus lug on the thermocouple holder, we will refer to this as flexible lead #2.

Remove the heater make up resistance (which usually is approximately 2.5 ohms) and solder a flexible lead (two feet long) to where the black lead of the thermocouple is soldered to the H connection lug. (Do not unsolder the black thermocouple lead from the H lug.) We will refer to this two foot flexible lead as flexible lead #3. Solder a two foot flexible lead to the loose black covered lead of the thermocouple, this will be referred to as flexible lead #4.



Allow the instrument and the connections you just soldered to temperature stabilize for about 1 hour at 25° centigrade.

Construct the circuit as shown on the previous page.

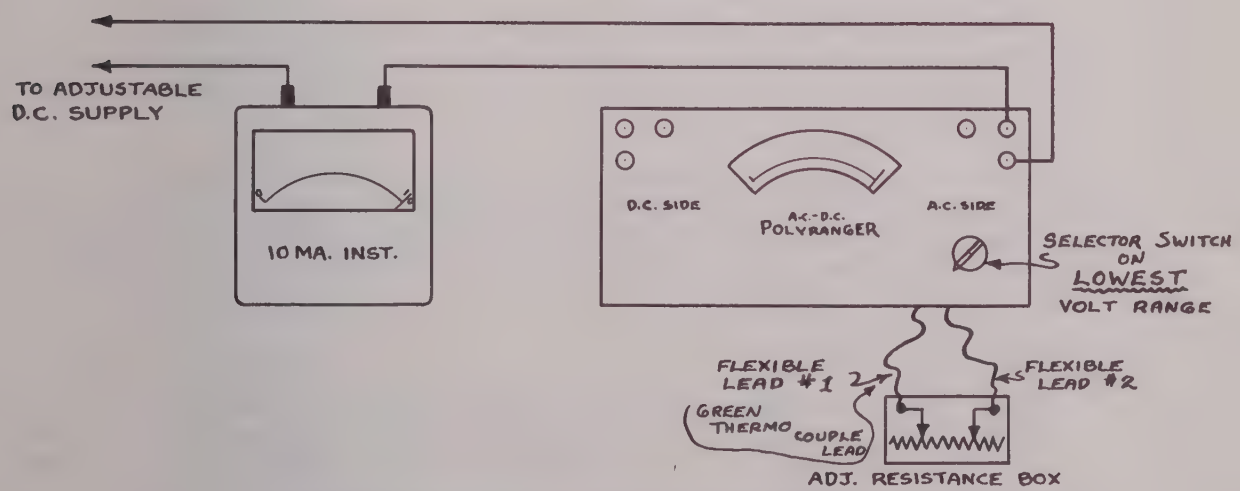
Adjust the D.C. current supply until the 10 instrument reads exactly full scale. Adjust the variable resistance box until the differential instrument reads exactly zero. Check that the 10 standard instrument still reads full scale.

Record the value of the adjustable resistance box and after removing the thermocouple from the test circuit, measure on a wheatstone bridge the resistance of the flexible copper leads numbered #3, #4 and #5. Add the values to the value of the resistance box. This combined value is the resistance required for the new heater make-up resistance.

Solder in this new resistance as previously written between a black lead from the thermocouple and the connection lug marked "H" on the moulded thermocouple holder.

After the instrument has been temperature stabilized at 25° centigrade, connect the Polyranger in a circuit such as shown below.

Set the selector switches so as to read the LOWEST VOLT RANGE (either .3 volt in the U-USP Polyrangers or .5 volt in the U-88 Polyranger). This assures that 10 Ma. will flow through the heater circuit and the A.C. universal shunt of the instrument CORRECTLY for full scale sensitivity adjustment as obtained below.




BASIC CALIBRATION CIRCUIT

Connect flexible lead #1 to one terminal of an adjustable resistance box and flexible lead #2 to the other terminal of the adjustable resistance box.

Adjust the supply circuit until the 10 Ma. standard instrument reads exactly 10 Ma. Adjust the resistance box so the TOP POINT of the polyranger reads exactly .3 volt or .5 volt depending on the polyranger being tested. These points will be the same as the full scale points of 10 or 15 Ma. depending on the model polyranger being calibrated.

Record the resistance of the adjustable box. At this time we can check the calibration of the polyranger. Check the polyranger calibration using the 10 Ma. standard instrument against the cardinal points of the polyranger.

In the case of the MODEL USP POLYRANGER the values are as follows:

| USP full scale value (15 Ma.) Cardinal scale points | Calibrating current with switch on .3 volt |
|---|---|
| 15 Ma. | 10.00 Ma. |
| 14 " | 9.33 " |
| 13 " | 8.66 " |
| 12 " | 8.00 " |
| 11 " | 7.33 " |
| 10 " | 6.66 " |
| 9 " | 6.00 " |
| 8 " | 5.33 " |
| 7 " | 4.66 " |
| 6 " | 4.00 " |
| 5 " | 3.33 " |
| 4 " | 2.66 " |
| 3 " | 2.00 " |
| 0 " | 0 |

Record the error of the POLYRANGER readings and make a correction chart.
See page # 185

After calibration unsolder the adjustable resistance box leads and measure the box and its leads on an accurate wheatstone bridge. This measured value will be the resistance required to be inserted as a sensitivity adjustment resistance between the green thermocouple lead and the negative (-) lug of the thermocouple holder.

Install the resistance.

The correction chart will be accurate on all A.C. ranges, provided the instrument has not been overloaded to the extent that the internal shunt and voltage resistances have been damaged.

Sensitive Research thermocouples have less than .1% universal therefore they can be checked on either A.C. or D.C.

To remove the old thermocouple, unsolder the following:

1. Red thermocouple lead from the plus connection lug.

2. The end of the resistor that goes to the minus connection lug.

3. The black lead from the H connection lug.

4. The end of the resistor that goes to the other H connection lug.

Remove the screws that hold the 2 resistors in place, grasp the four thermocouple leads near the base of the thermocouple and pull straight up. In our later models the thermocouple is installed in a piece of white foam rubber tubing

rubber tubing. When you lift the thermocouple out, the rubber tubing may come out with the thermocouple. If it does, merely pull the thermocouple out of the tubing. Then slip the new thermocouple into the tubing and insert them into the bakelite thermocouple holder, glass point down. Solder thermocouple leads with the 2 resistors which are supplied with the thermocouple back into place, reversing above procedure. Screw bakelite disk into the bottom of the case. Instrument is now ready for use.

The above operation is relatively simple and requires only a few minutes time. Inasmuch as the output characteristics of individual thermocouples vary a few percent within a particular type, a deviation curve is supplied with the new replacement thermocouple. The use of this correction curve with the original instrument scale will permit all readings to be taken within the instrument's guaranteed accuracy.